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A Plithogenic Statistical Approach to Digital Security Measures and Emotional Health in Childhood and Adolescence

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Abstract

The rapid digitalization of society has raised important concerns regarding the psychological and emotional well-being of minors navigating online environments. This study aims to analyze the relationship between digital security measures and the psychological resilience, self-esteem, and social interactions of children and adolescents. Utilizing a plithogenic statistical approach, which accounts for the complex, indeterminate nature of these variables, this study examined how various dimensions of digital security—including confidentiality, integrity, authentication, and access control—impact key aspects of minors' emotional well-being. Analysis of expert evaluations revealed that robust digital protections enhance emotional stability by reducing cyberbullying risks and fostering a supportive online environment, leading to higher self-esteem and healthier interpersonal relationships. These findings underscore the necessity for comprehensive educational programs that integrate both technical digital literacy and emotional management skills. Such programs can empower minors to navigate digital spaces securely and confidently, fostering overall psychological well-being in a digital age. Further research is recommended to expand on these findings and explore their applications across diverse socioeconomic contexts.

Keywords: Plithogenic set, Plithogenic statistics, Digital security, Psychological well-being, Online safety policies.

1 | Introduction

The rapid expansion of digital technology has transformed the interaction of children and adolescents with the world by providing opportunities for learning and socialization [1]. However, it also presents serious risks

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to their emotional and psychological safety, especially for those in vulnerable situations [2]. In fact, minors in digital environments face various threats that jeopardize their physical and emotional development [3].

Therefore, it is essential to address the situation of children and adolescents living in conditions of begging, as this reality presents a social challenge that requires urgent and multidisciplinary attention [4].

Furthermore, the lack of adequate protection leaves them vulnerable to abuse and deterioration of their mental health [5–7]. On the other hand, it is significant to identify the vulnerability factors that influence the relationship between digital security and the overall well-being of minors. Among these factors are:

- I. Socioeconomic context: minors from disadvantaged socioeconomic backgrounds have limited access to educational and technological resources, making it difficult for them to develop adequate skills to navigate safely in digital environments. Consequently, the lack of knowledge increases their exposure to online risks.
- II. Education and digital literacy: the lack of education on computer security and insufficient digital literacy leaves minors without the necessary tools to protect themselves from online threats. The absence of educational programs that promote cybersecurity knowledge contributes to their vulnerability [8], [9].
- III. Interpersonal relationships: minors who have difficulties in their family or social relationships are more likely to seek connection and acceptance online, leading them to expose themselves to risks such as cyberbullying or exploitation. Furthermore, these experiences severely affect their emotional and psychological well-being [10].
- IV. Psychological characteristics: some minors exhibit psychological traits that make them more susceptible to the negative effects of online interactions. Low self-esteem, anxiety, and depression are intensified by adverse digital experiences.
- V. Access to and use of technology: the type of devices used and the level of parental supervision are also significant factors. Unrestricted access to the internet without adequate control measures increases the risk of exposure to inappropriate content and dangerous situations [11].
- VI. Supportive environments: the presence or absence of support networks, whether familial, school-based, or community-oriented, influences minors' ability to cope with digital challenges.
- VII. Safety regulations and policies: the lack of effective policies in educational institutions and at home regarding the safe use of technology contributes to vulnerability [12], [13]. Therefore, without a clear structure and defined rules, minors lack guidance on how to behave safely in digital environments.
- VIII. Together, these vulnerability factors affect the relationship between digital security and the overall well-being of minors. Thus, they emphasize the need to address these dimensions through plithogenic statistics. To this end, the following general objective of the study is proposed:
- IX. Examine the relationship between computer security and psychological and emotional well-being in children and adolescents by identifying how digital protection measures influence their emotional stability, self-esteem, and quality of interpersonal relationships.

Specific objectives include:

- I. Analyze, using plithogenic statistics, how the dimensions of computer security variables impact the dimensions of the psychological and emotional well-being of children and adolescents.
- II. Analyze the intersections between the dimensions of computer security and emotional well-being to determine which digital protection practices are most effective in promoting a safe and emotionally healthy environment for children and adolescents.
- III. Develop strategies for the protection and promotion of minors' well-being in digital environments.

2 | Literature Review

2.1 | Plithogenic Statistics

Plithogenic statistics are applied to analyze complex data in the realm of digital security and the emotional well-being of children and adolescents. This technique allows for the investigation of how different factors of computer security influence aspects such as self-esteem and mental health. By employing plithogenic statistics, a better understanding of the interactions between the dimensions of each analyzed variable is obtained, and how they simultaneously affect the digital environment of minors. To implement this method, it is essential to define the plithogenic dynamics in the relationship between digital security and the overall well-being of children and adolescents in situations of vulnerability [14].

Plithogeny is the dynamic of various types of opposites and/or their neutrals and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (the dynamic of one type of opposites: $\langle A \rangle$ and $\langle \text{anti}A \rangle$) and neutrosophy (the dynamic of one type of opposites and their neutrals, $\langle A \rangle$ and $\langle \text{anti}A \rangle$ and $\langle \text{neut}A \rangle$), as Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites ($\langle A \rangle$ and $\langle \text{anti}A \rangle$ and $\langle \text{neut}A \rangle$, $\langle B \rangle$ and $\langle \text{anti}B \rangle$ and $\langle \text{neut}B \rangle$, etc.), along with many non-opposites ($\langle C \rangle$, $\langle D \rangle$, etc.) altogether. As an application and particular case derived from Plithogeny, the plithogenic set is an extension of the classical set, fuzzy set, intuitionistic fuzzy set, and neutrosophic set [15], [16]. Therefore, it is referred to as a plithogenic set (P, a, V, d, c).

- I. Where P is a set, a is an attribute (generally multidimensional), V is the range of values of the attribute, d is the degree of membership of the attribute value of each element x in the set P for given criteria ($x \in P$), and d represents d_F or d_{IF} or d_N , when it is a degree of fuzzy membership, intuitionistic fuzzy membership, or neutrosophic membership, respectively, of an element x in the plithogenic set P ;
- II. c signifies c_F or c_{IF} or c_N , when it is a function of the degree of contradiction of the fuzzy attribute value, a function of the degree of contradiction of the intuitionistic fuzzy attribute value, or a function of the degree of contradiction of the neutrosophic attribute value, respectively [17], [18].

Functions are defined according to the applications that experts need to solve. $d(\cdot, \cdot)$ and $c(\cdot, \cdot)$ are then used with the following notation: $x(d(x, V))$, where $d(x, V) = \{d(x, v) \text{ for all } v \in V\}$, for all $x \in P$. In fact, for the development of the study, bibliographic materials on the methodology of plithogenic logic were consulted [19], [20].

As for plithogenic statistics, it constitutes a methodology that focuses on the inclusion of indeterminacy, contradiction, and the interrelation of variables within a plithogenic set and its dimensions. Therefore, plithogenic statistical analysis allows for addressing the complexity of the perceptions of the analyzed sample. This requires a linguistic evaluation system adapted to the plithogenic model to accurately capture the opinions of the experts (see the section on the information of the analyzed variables).

Consequently, the dataset is evaluated, which is formed entirely or partially by data with some degree of indeterminacy and contradiction. To this end, the plithogenic statistical method is used to interpret and organize the plithogenic data to reveal underlying patterns [21], [22].

For the plithogenic statistical modeling in this study, a random variable P is referenced, representing the corresponding lower and upper levels that the studied plithogenic variable can reach within an indeterminate and contradictory interval. Thus, it follows the plithogenic mean of the variable ($\bar{P}$) when formulating.

$$\bar{P} = \frac{1}{n_P} \sum_{i=1}^{n_P} P_i, \quad (1)$$

where n_P is a plithogenic random sample from the studied population. Once the mean is defined, the calculation of the variance of the plithogenic sample proceeds. To do this, it is necessary to convert a

plithogenic number into a scalar number according to the methodology analyzed in the study materials. Subsequently, the following equation is defined for the calculation of S_P^2 :

$$S_P^2 = \frac{\sum_{i=1}^{n_P} (P_i - \bar{P}_i)^2}{n_P}. \quad (2)$$

Consequently, the plithogenic coefficient (CV_P) is calculated, which measures the consistency of the variable. The lower the value of CV_P , the more consistent the performance of the analyzed element is compared to the others studied. To this end, the following equation is proposed:

$$CV_P = \sqrt{S_P^2} \times 100. \quad (3)$$

2.2 | Information on the Analyzed Variables

Table 1 summarizes the variables and dimensions of the study on computer security and psychological and emotional well-being in children and adolescents. The following structure facilitates the understanding of the digital environment and its impact on the development of childhood and adolescence.

Table 1. Characteristics of the variables and their dimensions (source: own elaboration).

Code	Variables	Description	Code	Dimensions	Description
V1	Computer security	A set of measures, techniques, and procedures to protect information, systems, and networks in the digital environment of children and adolescents.	D1	Confidentiality	Protection of sensitive information of children and adolescents against unauthorized access. Ensures that only authorized individuals can access it.
			D2	Integrity	Protection of the information of children and adolescents against unauthorized modifications. Ensures that the data is not altered.
			D3	Authentication	Verification of the identity of young users and authentication of their access credentials. Ensures that only authorized individuals can access it.
			D4	Access management	Administration of access permissions to systems and digital resources used by children and adolescents. Each user has privileges according to their responsibilities.
V2	Psychological and emotional well-being	General state of the mental and emotional health of children and adolescents, including the ability to manage stress, regulate their emotions, and establish healthy relationships.	D5	Mental health	The ability of children and adolescents to maintain emotional balance and face life's challenges by adequately managing their emotions.

Table 1. Continued.

Code	Variables	Description	Code	Dimensions	Description
V2	Psychological and emotional well-being	General state of the mental and emotional health of children and adolescents, including the ability to manage stress, regulate their emotions, and establish healthy relationships.	D6	Self-esteem and self-concept	The perception and evaluation that children and adolescents have of themselves. Includes confidence in their abilities and acceptance of their identity.
			D7	Interpersonal relationships	The quality of the relationships that children and adolescents establish with their family, friends, and others. Ability to communicate, resolve conflicts, and receive emotional support.
			D8	Emotional well-being	The ability of children and adolescents to recognize, understand, and healthily express their emotions. Includes the adequate management of emotions and the experience of positive emotions.

Consequently, the plithogenic measurement scales for the eight dimensions analyzed in the plithogenic set encompassing computer security and the psychological and emotional well-being of children and adolescents are presented. Each scale includes a description of the levels of importance or frequency evaluated by the experts, as well as the corresponding plithogenic numbers (*Tables 2-9*).

Table 2. Confidentiality dimension (D1) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Total protection of sensitive information, with no unauthorized access.
Very High (VH)	8	(0.75,0.15,0.1)	0.70	High protection of information, with minimal access breaches
High (H)	7	(0.6,0.25,0.2)	0.55	Significant protection, although some unauthorized access exists.
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate protection, with possible unauthorized access.
Low (L)	3	(0.4,0.45,0.4)	0.35	Low protection of information, with high risks of unauthorized access.

Table 3. Integrity dimension (D2) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Total protection against unauthorized modifications of information.
Very High (VH)	8	(0.75,0.15,0.1)	0.70	High protection, with minimal possibilities of data alteration
High (H)	7	(0.6,0.25,0.2)	0.55	Significant protection, although minor alterations occur
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate protection, with risk of alterations
Low (L)	3	(0.4,0.45,0.4)	0.35	Low protection, with a high probability of unauthorized alterations.

Table 4. Authentication dimension (D3) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Total authentication, ensuring that only authorized users have access.
Very High (VH)	8	(0.75,0.15,0.1)	0.70	High authentication, with minimal failures in identity verification.
High (H)	7	(0.6,0.25,0.2)	0.55	Significant authentication, although with some occasional errors.
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate authentication, with risks of unauthorized access.
Low (L)	3	(0.4,0.45,0.4)	0.35	Low authentication, with a high possibility of unauthorized access.

Table 5. Access management dimension (D4) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Total access management, ensuring that only authorized individuals can access.
Very High (VH)	8	(0.75,0.15,0.1)	0.70	High management, with minimal gaps in access
High (H)	7	(0.6,0.25,0.2)	0.55	Significant management, although some unauthorized access may occur.

Table 5. Continued.

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate management, with the possibility of inappropriate access
Low (L)	3	(0.4,0.45,0.4)	0.35	Low access management, with high risks of unauthorized access

Table 6. Mental health dimension (D5) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Optimal mental health, with complete emotional balance
Very High (VH)	8	(0.75,0.15,0.1)	0.70	High mental health, with good emotional management abilities
High (H)	7	(0.6,0.25,0.2)	0.55	Significant mental health, with adequate stress management
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate mental health, with some challenges in emotional management
Low (L)	3	(0.4,0.45,0.4)	0.35	Low mental health, with difficulties in managing emotions

Table 7. Self-esteem and self-concept dimension (D6) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Optimal self-esteem, with high self-confidence
Very High (VH)	8	(0.75,0.15,0.1)	0.70	High self-esteem, with good acceptance of identity
High (H)	7	(0.6,0.25,0.2)	0.55	Significant self-esteem, although with some doubts
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate self-esteem, with mixed self-perceptions
Low (L)	3	(0.4,0.45,0.4)	0.35	Low self-esteem, with notable insecurities

Table 8. Interpersonal relationships dimension (D7) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Optimal interpersonal relationships, with effective communication
Very High (VH)	8	(0.75,0.15,0.1)	0.70	Very good relationships, with emotional support and appropriate communication
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate interpersonal relationships, with challenges in communication
Low (L)	3	(0.4,0.45,0.4)	0.35	Weak interpersonal relationships, with frequent conflicts
High (H)	7	(0.6,0.25,0.2)	0.55	Good interpersonal relationships, although with some conflicts

Table 9. Emotional well-being dimension (D8) (source: own elaboration).

Linguistic Expression	Scale	Plithogenic Number (T, I, F)	S ([T,I,F])	Description
Extremely High (EH)	10	(0.9,0.05,0.05)	0.90	Optimal emotional well-being, with excellent emotional regulation
Very High (VH)	8	(0.75,0.15,0.1)	0.70	Very good emotional well-being, with the ability to express healthy emotions
High (H)	7	(0.6,0.25,0.2)	0.55	Good emotional well-being, although with occasional difficulties
Medium (M)	5	(0.5,0.35,0.3)	0.45	Moderate emotional well-being, with challenges in expressing emotions
Low (L)	3	(0.4,0.45,0.4)	0.35	Low emotional well-being, with difficulties in emotional regulation

To determine the value of $S([T, I, F])$, the following *Formula (4)* is applied. This allows for converting a triple plithogenic number into a single value.

$$S([T, I, F]) = T + F - I. \quad (4)$$

3 | Results

3.1 | Modeling of Plithogenic Statistics

When modeling plithogenic statistics, the necessary frequencies are obtained to determine the level of importance of each dimension of the variables of computer security (V1) and psychological and emotional well-being (V2) (*Tables 11 and 12*). For the statistical development, a sample of 60 experts was used, including professionals from various disciplines such as psychologists, lawyers, and systems engineers, in order to provide a comprehensive perspective on the study variables. Therefore, each dimension was evaluated according to the proposed plithogenic scale, as indicated in *Tables 2-9*.

Table 10. Plithogenic frequency for variables V1 and V2. source: own elaboration.

Expert	Variable V1				Variable V2			
	D1	D2	D3	D4	D5	D6	D7	D8
1	(0.66,0.66)	(0.58,0.84)	(0.42,0.62)	(0.78,0.95)	(0.27,0.73)	(0.28,0.77)	(0.27,0.62)	(0.62,0.93)
2	(0.69,0.88)	(0.63,0.9)	(0.58,0.74)	(0.71,0.9)	(0.35,0.79)	(0.45,0.9)	(0.46,0.82)	(0.55,0.89)
3	(0.8,0.92)	(0.6,0.87)	(0.62,0.77)	(0.7,0.9)	(0.45,0.85)	(0.43,0.85)	(0.2,0.59)	(0.6,0.84)
4	(0.6,0.77)	(0.56,0.82)	(0.39,0.5)	(0.79,0.97)	(0.2,0.63)	(0.27,0.68)	(0.1,0.5)	(0.62,0.92)
5	(0.51,0.55)	(0.56,0.81)	(0.21,0.4)	(0.77,0.93)	(0.3,0.78)	(0.2,0.63)	(0.16,0.52)	(0.64,0.9)
6	(0.64,0.71)	(0.62,0.9)	(0.46,0.6)	(0.79,0.97)	(0.39,0.81)	(0.36,0.76)	(0.27,0.62)	(0.56,0.81)
7	(0.79,0.88)	(0.6,0.89)	(0.56,0.74)	(0.73,0.9)	(0.38,0.78)	(0.39,0.82)	(0.53,0.88)	(0.58,0.76)
8	(0.67,0.73)	(0.7,0.95)	(0.52,0.71)	(0.73,0.92)	(0.29,0.75)	(0.49,0.9)	(0.46,0.85)	(0.6,0.85)
9	(0.6,0.75)	(0.5,0.77)	(0.65,0.8)	(0.75,0.95)	(0.21,0.64)	(0.28,0.7)	(0.44,0.81)	(0.57,0.9)
10	(0.61,0.64)	(0.54,0.83)	(0.33,0.53)	(0.8,0.99)	(0.2,0.67)	(0.28,0.74)	(0.53,0.88)	(0.58,0.73)
11	(0.71,0.85)	(0.54,0.83)	(0.39,0.51)	(0.78,0.93)	(0.46,0.96)	(0.37,0.82)	(0.59,0.98)	(0.62,0.83)
12	(0.54,0.64)	(0.62,0.87)	(0.55,0.71)	(0.79,0.95)	(0.46,0.87)	(0.45,0.87)	(0.47,0.83)	(0.55,0.71)
13	(0.54,0.73)	(0.52,0.82)	(0.65,0.8)	(0.79,0.95)	(0.37,0.77)	(0.22,0.72)	(0.49,0.84)	(0.63,0.89)
14	(0.76,0.94)	(0.55,0.81)	(0.23,0.39)	(0.77,0.95)	(0.24,0.66)	(0.22,0.68)	(0.24,0.62)	(0.57,0.8)
15	(0.75,0.79)	(0.65,0.91)	(0.34,0.44)	(0.74,0.93)	(0.28,0.7)	(0.3,0.77)	(0.43,0.78)	(0.62,0.83)
16	(0.53,0.55)	(0.57,0.84)	(0.39,0.51)	(0.77,0.95)	(0.22,0.67)	(0.42,0.87)	(0.1,0.48)	(0.58,0.82)
17	(0.64,0.72)	(0.7,0.97)	(0.64,0.84)	(0.73,0.9)	(0.36,0.83)	(0.39,0.85)	(0.49,0.89)	(0.55,0.8)
18	(0.55,0.64)	(0.7,0.99)	(0.63,0.76)	(0.8,0.96)	(0.44,0.88)	(0.41,0.89)	(0.46,0.86)	(0.57,0.85)
19	(0.79,0.82)	(0.52,0.79)	(0.54,0.73)	(0.73,0.9)	(0.26,0.67)	(0.4,0.81)	(0.22,0.62)	(0.55,0.83)
20	(0.65,0.84)	(0.67,0.92)	(0.56,0.71)	(0.72,0.88)	(0.48,0.93)	(0.45,0.92)	(0.47,0.87)	(0.61,0.89)
21	(0.6,0.72)	(0.7,0.95)	(0.24,0.34)	(0.8,0.99)	(0.3,0.74)	(0.33,0.75)	(0.6,0.99)	(0.65,0.97)
22	(0.75,0.84)	(0.7,0.96)	(0.37,0.57)	(0.79,0.94)	(0.44,0.91)	(0.27,0.73)	(0.43,0.79)	(0.55,0.72)
23	(0.63,0.75)	(0.55,0.83)	(0.65,0.85)	(0.79,0.99)	(0.23,0.73)	(0.4,0.82)	(0.53,0.9)	(0.64,0.81)
24	(0.51,0.71)	(0.67,0.95)	(0.67,0.85)	(0.76,0.96)	(0.27,0.71)	(0.48,0.88)	(0.37,0.76)	(0.58,0.87)
25	(0.5,0.66)	(0.53,0.82)	(0.28,0.41)	(0.71,0.89)	(0.28,0.74)	(0.23,0.7)	(0.53,0.91)	(0.62,0.9)
26	(0.73,0.9)	(0.51,0.79)	(0.29,0.39)	(0.75,0.93)	(0.47,0.88)	(0.46,0.95)	(0.32,0.67)	(0.58,0.77)
27	(0.58,0.67)	(0.56,0.86)	(0.26,0.42)	(0.79,0.96)	(0.46,0.89)	(0.27,0.71)	(0.33,0.72)	(0.6,0.86)
28	(0.79,0.91)	(0.53,0.79)	(0.39,0.53)	(0.79,0.95)	(0.28,0.76)	(0.31,0.81)	(0.12,0.49)	(0.62,0.9)
29	(0.51,0.67)	(0.65,0.95)	(0.6,0.8)	(0.71,0.9)	(0.25,0.74)	(0.26,0.76)	(0.41,0.8)	(0.65,0.82)
30	(0.78,0.84)	(0.65,0.9)	(0.47,0.61)	(0.71,0.9)	(0.22,0.68)	(0.49,0.9)	(0.23,0.59)	(0.63,0.88)
0-60	(41.43,47.98)	(38.02,55.25)	(27.41,37.08)	(47.55,58.65)	(21.06,49.27)	(22.51,50.88)	(20.65,44.05)	(37.78,53.26)

Table 11. Plithogenic statistical analysis of variables V1 and V2 (source: own elaboration).

Dimension	$\bar{P}$	S_p	CV_p
D1	0.69 + 0.8 I	0.082 + 0.097 I	0.119 + 0.121 I
D2	0.63 + 0.92 I	0.058 + 0.066 I	0.092 + 0.072 I
D3	0.46 + 0.62 I	0.12 + 0.127 I	0.261 + 0.205 I
D4	0.79 + 0.98 I	0.04 + 0.051 I	0.051 + 0.052 I
D5	0.35 + 0.82 I	0.078 + 0.083 I	0.223 + 0.101 I
D6	0.38 + 0.85 I	0.074 + 0.079 I	0.195 + 0.093 I
D7	0.34 + 0.73 I	0.133 + 0.14 I	0.391 + 0.192 I
D8	0.63 + 0.89 I	0.037 + 0.068 I	0.059 + 0.076 I

Tables 10 and 11 shows the range of expert perceptions of the interrelation of variables V1 and V2, through their dimensions. An analysis of the plithogenic frequencies is then carried out.

- I. Dimension D1: a very high level of confidentiality (VH) positively influences the emotional state of children. By protecting personal information from unauthorized access, stress related to digital exposure is reduced, which in turn supports emotional regulation. The indeterminate part, close to extremely high (EH), suggests that increasing confidentiality has a very positive impact on emotional stability by reducing concerns about online security.
- II. Dimension D2: a high level of information integrity (H-VH) reduces the likelihood that children's and adolescents' personal data will be manipulated or altered. This improves their ability to manage stress by creating a more trustworthy and secure environment, allowing them to focus on their relationships and emotions. Therefore, an environment with strong data integrity reinforces trust and decreases anxiety levels.
- III. Dimension D3: authentication is at a moderate (M) level in its ability to protect data, suggesting a higher risk of unauthorized access. This creates insecurities and fears in children, negatively affecting their emotional well-being. Children experience difficulties regulating their emotions due to uncertainty about who has access to their information, which causes anxiety. However, at high levels of authentication, these risks are minimized, enhancing children's ability to feel safe and emotionally stable.
- IV. Dimension D4: extremely high access control (EH) ensures that only authorized individuals interact with children's data, which has a very positive impact on their emotional well-being and their ability to form healthy relationships. Indeed, children feel safer knowing there is proper management of access permissions. This reinforces their confidence in the digital environment and enhances their willingness to interact healthily with others.
- V. Dimension D5: children's mental health is at a low level (L), as it is related to inadequate computer security measures. The lack of security creates an environment of uncertainty, impacting children's mental well-being. However, the indeterminate portion in the very high-extremely high (VH-EH) zone suggests that in environments where security measures are effective, children experience better emotional management, with reduced stress and enhanced emotional balance.
- VI. Dimension D6: children and adolescents' self-esteem is affected by low levels of computer security. In contexts where data protection is weak, children experience insecurities about their privacy, which negatively impacts their self-concept. However, when security levels are high, as indicated in the indeterminate portion (VH-EH), children develop a more positive self-concept, trusting that their information is protected and thus improving their self-esteem.
- VII. Dimension D7: interpersonal relationships are strongly influenced by the protection offered by digital security. A low value (L) indicates that when security is insufficient, children experience difficulties in establishing healthy relationships due to a lack of trust in the digital environment. However, in environments with a high level of computer security, better communication and emotional support among children are promoted, fostering more positive interpersonal relationships.
- VIII. Dimension D8: a high level of emotional well-being is directly related to effective digital protection. The fact that children feel safe in their digital interactions allows them to experience better emotional control and a greater ability to regulate their emotions. When computer security is very high (VH-EH), children enjoy an environment where they can express their emotions in a healthy way, which enhances their overall well-being.

Comparative analysis between dimensions:

- I. Stability: dimensions D1, D2, and D4 show low values in standard deviation, indicating a more stable perception of confidentiality, integrity, and access control. In contrast, D3 and D7 have higher values, suggesting that authentication and interpersonal relationships are more susceptible to changes in security perception.
- II. Trust: in terms of variable consistency, D4 has the lowest value, indicating that access control is perceived as highly consistent and reliable. D2 also shows low variable consistency, while D3 and D7 present the highest values. This suggests that insecurity in authentication and interpersonal relationships significantly affects emotional well-being.

- III. Emotional influence: D3 and D7 are crucial for emotional well-being, showing that insecurity in authentication and interpersonal relationships leads to anxiety and emotional problems. In contrast, D4, with its low variability and consistency of the variable, shows a positive impact on healthy relationships.
- IV. Relationship with well-being: Although all dimensions influence emotional well-being, D8 stands out for its stability, indicating that a constant perception of security is essential for maintaining positive emotional well-being.

3.2 | Relationship between Variables within the Plithogenic Set

The plithogenic integration allows for the analysis of the intersection and union of the dimensions associated with variables V1 and V2, to understand how protection in the digital environment influences the emotional and psychological state of minors. Below are the relationships of intersection, union, levels of contradiction, and areas of belonging between the dimensions of variables V1 and V2 based on the plithogenic results obtained.

First, the relationships of interception allow for the identification of areas where the dimensions of V1 and V2 coincide, showing how security in the digital environment interacts with the emotional well-being of minors. Among those perceived are:

- I. Interception between D1 (confidentiality) and D5 (mental health): the interception between data confidentiality and mental health presents a significant relationship in plithogenic areas ranging from high (H) to very high (VH). It highlights that a digital environment that respects privacy and protects minors' information favors their emotional balance and ability to manage stress. This overlap suggests that by ensuring confidentiality, anxiety generated by the exposure of sensitive data is reduced.
- II. Interception between D2 (integrity) and D6 (self-esteem and self-concept): the values indicate an interception in a zone ranging from very high (VH) to extremely high (EH), where maintaining digital integrity directly impacts minors' self-esteem. By ensuring the truthfulness and protection of information, children and adolescents develop greater confidence in their digital identity, contributing to a positive self-perception.
- III. Interception between D3 (authentication) and D7 (interpersonal relationships): this intersection is found in a range from medium (M) to very high (VH). It suggests that authentication, by limiting unauthorized access to social networks and other digital environments, influences the quality of interpersonal relationships. In fact, effective authentication tools reduce the risk of negative interactions, fostering safer and more respectful relationships in the digital realm.
- IV. Interception between D4 (access management) and D8 (emotional well-being): the relationship between these dimensions is located in an area of intersection from high (A) to extremely high (EH), showing that proper management of digital access significantly contributes to emotional well-being. Similarly, the perception of security, derived from the controlled administration of permissions and access, alleviates stress and facilitates stable emotional regulation.
- V. In the second place, the union relationships between the dimensions of V1 and V2 show how the combination of various digital security practices collectively promotes the emotional well-being of minors in digital environments.

Among those highlighted are:

- VI. Union of D1 (confidentiality) and D2 (integrity) with D5 (mental health): the union of these dimensions highlights how the comprehensive protection of confidentiality and integrity strengthens mental health, as it provides a safe and reliable foundation on which minors interact without fear of exposure or manipulation of their information. This union creates a digital environment that significantly reduces the stress associated with technology use.
- VII. Union of D3 (authentication) and D4 (access management) with D7 (interpersonal relationships): the combination of rigorous authentication and efficient access management enables healthier interpersonal relationships by preventing contact with unauthorized or potentially dangerous individuals. This suggests

that a well-managed digital environment not only protects information but also promotes positive and enriching interactions.

- VIII. Union of D2 (integrity) and D6 (self-esteem): the union between information integrity and minors' self-concept demonstrates how certainty about data reliability strengthens self-esteem and self-confidence in the digital environment. This combination is crucial to prevent minors from facing situations of misinformation or deception that could negatively impact their self-perception.
- IX. Finally, the levels of contradiction in the plithogenic analysis reveal possible tensions between the dimensions of V1 and V2, while the areas of belonging show the degree of affinity between them, as observed below:
 - X. Contradiction between D1 (confidentiality) and D6 (self-esteem): a slight level of contradiction is observed when confidentiality is insufficient, as it affects the self-esteem of minors. Without the security of their private information, minors develop insecurities that impact their self-perception in the digital environment.
 - XI. Area of belonging between D2 (integrity) and D5 (mental health): the area of belonging between these dimensions is broad and encompasses high (A) to extremely high (EA) levels, indicating that maintaining digital integrity significantly contributes to a stable mental health state. Security in data integrity reduces uncertainty and provides a foundation for emotional stability.
 - XII. Contradiction between D3 (authentication) and D7 (interpersonal relationships): a moderate level of contradiction suggests that if authentication systems are perceived as restrictive, it would limit minors' ability to interact with others in digital environments, generating frustration or social isolation.
- XIII. The plithogenic analysis between digital integrity and emotional well-being highlights how a digital environment that adequately protects the integrity and confidentiality of information has a positive effect on the emotional health of minors. It even includes those who are in vulnerable conditions, such as children and adolescents living in poverty. This plithogenic set suggests that a security infrastructure not only prevents cybersecurity risks but also establishes a trustworthy digital environment, which is essential for the development of emotional and social competencies in children and adolescents in the digital age.

3.3 | Strategies for Protecting and Promoting the Well-Being of Minors in Digital Environments

The development of educational strategies that raise awareness about the need for digital security and its impact on the well-being of vulnerable minors is essential for creating a safer and healthier online environment. Below are various strategies in the educational field:

I. Awareness programs in schools:

- *Workshops and seminars: Organize regular workshops in schools that include topics on cybersecurity, online risks, and the emotional impact of digital experiences. These workshops would include participation from experts in child safety and psychology.*
- *Interactive Talks: Invite cybersecurity and mental health professionals to offer interactive talks that address real-life cases and discuss the consequences of cyberbullying, exposure to inappropriate content, and other digital threats.*

II. Incorporation into the school curriculum:

- *Digital education subjects: Develop a curriculum that includes subjects on digital education that address online safety, responsible use of social media, and the need to protect personal information.*
- *Problem-based learning projects: Encourage the creation of projects where students identify problems related to digital security and propose solutions, promoting active and collaborative learning.*

III. Educational resources and online tools:

- *Interactive platforms: Create online educational platforms that offer resources on digital security, including games, quizzes, and simulations that help children understand and apply cybersecurity concepts playfully.*
- *Information guides and brochures: Develop guides and brochures aimed at parents and educators, providing clear information on how to address digital safety and the emotional well-being of minors.*

IV. Mentoring and support programs:

- *Peer mentoring: Establish mentoring programs where older students act as mentors to minors in vulnerable situations, providing support in understanding online safety and offering a safe space to discuss concerns.*
- *Support Groups: Create support groups within schools where young people share experiences, learn from each other, and receive guidance on how to face digital challenges.*

V. Involvement of parents and community:

- *Parent Workshops: Conduct training workshops for parents on digital risks and strategies for fostering a safe environment at home, including how to supervise device use and promote open conversations about online experiences.*
- *Community Collaboration: Establish partnerships with local organizations and NGOs working on cybersecurity and child welfare issues to develop joint programs that expand the reach and impact of awareness efforts.*

VI. Evaluation and feedback:

- *Evaluation surveys: Implement surveys to evaluate the effectiveness of educational strategies and collect feedback from students, parents, and educators. This would allow programs to be adjusted and improved based on identified needs.*
- *Monitoring outcomes: Track incidents related to digital security and emotional well-being within the student population to measure the impact of implemented interventions.*
- *These educational strategies, aimed at raising awareness about the priority of digital security, not only protect vulnerable minors but also promote a healthier and safer school environment. By combining education with practice and community support, a significant change in the perception and management of digital risks is fostered, contributing to the overall well-being of young people.*

4 | Discussion

The relationship between digital security and the emotional well-being of children and adolescents has become highly relevant today. The plithogenic statistical analysis has shown that a safe digital environment not only protects personal information but also supports the emotional development of minors, especially those in vulnerable situations. The lack of knowledge about digital security has led to negative consequences, such as cyberbullying and exposure to harmful content. Therefore, it is essential to implement educational programs that teach both technical skills and emotional management in digital environments, fostering an atmosphere where minors feel safe to discuss their concerns.

Furthermore, the role of family and community is significant in protecting the emotional well-being of minors. Collaboration among parents, educators, and organizations establishes a solid support system to inform minors about online risks and promote a space of trust. However, the study also identified limitations, such as the duration of interventions and the lack of long-term follow-up. This highlights the need for future research to address these limitations and consider socioeconomic factors that influence the effectiveness of educational strategies on digital security.

5 | Conclusion

The plithogenic statistical analysis has revealed that digital security and the emotional well-being of children and adolescents are intrinsically related, highlighting that a safe online environment protects personal information and promotes healthy emotional development. Additionally, this study has identified the need for comprehensive educational programs that address both technical skills and the emotional impact of digital experiences.

The study presented limitations, such as the lack of long-term follow-up and insufficient consideration of socioeconomic factors that would influence the effectiveness of interventions, especially for minors in vulnerable situations. Therefore, further studies should be conducted to address these limitations and examine how educational strategies and security measures adapt to various cultural realities. This includes social contexts where the impact of digital security and the overall well-being of minors can be maximized.

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Author Contribution

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Data Availability

The data used in this study are available upon request from the corresponding author, subject to ethical or legal restrictions.

Conflicts of Interest

The authors declare no conflict of interest.

References

- [1] d'Halluin, A., Costa, M., Morgiève, M., & Sebbane, D. (2023). Attitudes of children, adolescents, and their parents toward digital health interventions: scoping review. *Journal of medical internet research*, 25, e43102. DOI:10.2196/43102
- [2] El-Asam, A., Katz, A., Street, C., Nazar, N. M., & Livanou, M. (2021). Children's services for the digital age: a qualitative study into current procedures and online risks among service users. *Children and youth services review*, 122, 105872. DOI:10.1016/j.childyouth.2020.105872
- [3] Health, T. L. D. (2020). Child and adolescent health in the digital age. *The lancet digital health*, 2(3), e102. DOI:10.1016/S2589-7500(20)30029-7
- [4] Jang, Y., & Ko, B. (2023). Online safety for children and youth under the 4cs framework a focus on digital policies in australia, canada, and the UK. *Children*, 10(8). DOI:10.3390/children10081415
- [5] Lafton, T., Holmarsdottir, H. B., Kapella, O., Sisask, M., & Zinoveva, L. (2023). Children's vulnerability to digital technology within the family: a scoping review. *Societies*, 13(1). DOI:10.3390/soc13010011
- [6] Vasconcelos, F., & Eisenstein, E. (2022). Hazardous gaming: challenges in the social media involving children and adolescents. *Current pediatrics reports*, 10(4), 235–240. DOI:10.1007/s40124-022-00277-w

- [7] Sağlam, R. B., Miller, V., & Franqueira, V. N. L. (2023). A systematic literature review on cyber security education for children. *IEEE transactions on education*, 66(3), 274–286. DOI:10.1109/TE.2022.3231019
- [8] Núñez-Gómez, P., Larrañaga, K. P., Rangel, C., & Ortega-Mohedano, F. (2021). Critical analysis of the risks in the use of the internet and social networks in childhood and adolescence. *Frontiers in psychology*, 12, 683384. <https://www.frontiersin.org/articles/10.3389/fpsyg.2021.683384/full>
- [9] Montag, C., Demetrovics, Z., Elhai, J. D., Grant, D., Koning, I., Rumpf, H. J., ... & van den Eijnden, R. (2024). Problematic social media use in childhood and adolescence. *Addictive behaviors*, 153, 107980. DOI:10.1016/j.addbeh.2024.107980
- [10] Peraza-Balderrama, J. N., Valdés-Cuervo, Á. A., Parra-Pérez, L. G., & Urias-Murrieta, M. (2024). Multidimensional scale to assess digital security in adolescents. *Electronic journal of educational research*, 26, e06. https://www.scielo.org.mx/scielo.php?pid=S1607-40412024000100106&script=sci_arttext
- [11] Dey, S., & Ray, G. C. (2023). Properties of redefined neutrosophic composite relation. *Neutrosophic systems with applications*, 7, 1–12. <https://sciencesforce.com/index.php/nswa/article/view/141>
- [12] Gutiérrez, P. B., Flores-Ledesma, K. N., Gómez, S. L. G., Bulnes, J. L. L., Nakayo, J. L. J., Carranza, C. F. C., & Ayala, A. C. N. (2023). Plithogenic Iadov model to study university teaching practices in the complexity of the educational process of comprehensive training by competencies. *Neutrosophic sets and systems*, 62(1), 10. https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=2526&context=nss_journal
- [13] Nabeeh, N. A., Sallam, K. M., & Mohamed, A. W. (2023). An electric vehicle analysis model for sustainable environment in devoicing nationals. *Neutrosophic systems with applications*, 6, 1–8. <https://sciencesforce.com/index.php/nswa/article/view/136>
- [14] Aldaz, E. C. M., Torres, R. E. O., Andi, S. T. T., & Quinchuela, F. B. M. (2022). Neutrosophic statistical analysis of self-assessment of rehabilitation knowledge in university students. *Neutrosophic sets and systems*, 52(1), 33. https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=2206&context=nss_journal
- [15] Smarandache, F. (2024). *Super hiper función y super hiper estructura y sus correspondientes super hiper función neutrosófica y super hiper estructura neutrosófica*. Infinite Study.
- [16] Monar Verdezoto, M. A., Rojas Sánchez, H. A., Rojas Urbano, J. A., & Briceño, J. (2024). Plithogenic hypothesis in social innovation: an analysis of its evolution and its relationship with the social economy. *Neutrosophic sets and systems*, 71(1), 6. https://digitalrepository.unm.edu/nss_journal/vol71/iss1/6/
- [17] González-Caballero, E., Leyva-Vázquez, M., & Smarandache, F. (2021). On neutrosophic uninorms. *Neutrosophic sets and systems*, 45(1), 22. https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1923&context=nss_journal
- [18] Vázquez, M. L., Franco, P. E. D. P., & Palacio, A. J. P. (2022). Neutrosophic dematel in the analysis of the causal factors of youth violence. *International journal of neutrosophic science*, 18(3), 199-207.
- [19] Martin, N., Smarandache, F., & Sudha, S. (2023). A novel method of decision making based on plithogenic contradictions. *Neutrosophic systems with applications*, 10, 12–24. <https://sciencesforce.com/index.php/nswa/article/view/163>
- [20] Abdelhafeez, A., Aziz, A., & Khalil, N. (2022). Building a sustainable social feedback loop: a machine intelligence approach for Twitter opinion mining. *Sustainable machine intelligence journal*, 1, 1–6. <http://sciencesforce.com/index.php/smij/article/view/33>
- [21] Alabdullah, M. R. (2023). The neutrosophic regular and most important properties that bind neutrosophic ring elements. *Neutrosophic sets and systems*, 61(1), 1. https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=2485&context=nss_journal
- [22] De Burca, S. (2020). Child and adolescent health in the digital age. *Lancet digit health*, 2, 102. [https://www.thelancet.com/journals/landig/article/PIIS2589-7500\(20\)30029-7/fulltext](https://www.thelancet.com/journals/landig/article/PIIS2589-7500(20)30029-7/fulltext)